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Treatment of Developmental Dysplasia of the Hip with Salter Innominate Osteotomy Method

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ABSTRACT

Background: In this study, we aim to show that salter innominate osteotomy treatment method is effective in maintaining the hip stability and yielding successful results with the support of soft tissue in patients diagnosed with developmental dysplasia of the hip (DDH) and those with unilateral developmental dysplasia of the hip over 18 months. The most important factor in developmental dysplasia of the hip yielding the result is diagnosis and the time of treatment, so it is possible to obtain near-normal results. Salter operation is a current and successful method on condition that pre-operative rules and operation techniques are applied completely and thoroughly in children aged over 1,5. Corrective osteotomies should be added to femoral head in this operation for children aged over four. **Methods:** A total of 7 patients aged between 19-26 months with unilateral developmental dysplasia of the hip on whom we applied salter innominate osteotomy on different dates were included in our study. In the study, a treatment was performed through salter innominate osteotomy on various dates to 7 patients of the age range of 19-26 months who had total unilateral developmental hip dislocation. **Results:** Quadriceps were given to the hips of all patients from iliac crest with anterior incision under general anesthesia. Salter innominate osteotomy was applied. **Conclusion:** In post-op, balanced walking was ensured in 2.5-4.5 months in all patients without any complications except the simple ones (migration of Kirschner wire and soft tissue infection).

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INTRODUCTION

The most important factor in developmental dysplasia of the hip determining the result is diagnosis and the time of treatment, so it is possible to obtain near-normal results (Tümer and Ömeroğlu, 1997). When diagnosis and treatment delay, the success rate falls and accordingly the rate of complication increases (Altınel, 1994). A complete treatment of developmental dysplasia of the hip without any residual dysplasia determines the person's quality of life in adolescence and adulthood. This great potential for the improvement in cases of developmental dysplasia of the hip in the period up to 18 months ensures the pretty good respond to conservative methods. However, the respond of acetabulum and femoral head to conservative methods after this age is inadequate, and a residual dysplasia or subluxation is faced in the future (Ünüvar, 2006).

In addition to the soft tissue pathologies that developed in DDH, the existence of bone pathologies developing in acetabulum and femur prevent standardization in surgical method. The purpose in DDH treatment should be obtaining stable and concordant joint by lowering femoral head to acetabulum (Tachdjian, 2002, Vural, *et al*., 2008).

Salter stated that a structural development defect exists in the front, top and side edges of acetabular roof in most of the cases of dysplasia of the hip, and accordingly frontal dysplasia occurs in extension and lateral dysplasia in adduction. So he performed osteotomy between spina iliaca anterior superior and sciatic notch and rotated the distal part around pubis to the front, sideways and below like a
louver in order to correct this structural defect (Salter, 1961, Salter and Dubos, 1974, Fredensborg and Nilsson, 1976, Vural, *et al*., 2008).

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Innominate bone osteotomy as defined by Salter in dislocated and/or subluxated dysplasia of the hip changes the orientation of the acetabulum with a bad position without changing the shape and capacity, and increases the load field of acetabulum, so this positively affects the development of acetabulum (Salter, 1961, Pemberton, 1965, Güner, *et al*., 1997, Aksoy and Kara, 1997). Salter blazed a trail in DDH treatment after publishing this method in 1961 (Salter, 1961, Salter and Dubos, 1974, Kapukaya, *et al*., 2000). Salter and Dubos (1974) have stated 94% perfect and good results with this method in children aged between 18 months and 4 years (Sarban, *et al*., 2006, Altınel, 1994, Weinstein and Ponseti, 1979). Treatment methods and salter innominate osteotomy method in the treatment of developmental dysplasia of the hip will be discussed in this study.

Epidemiology and Etiology:

The prevalence of developmental dysplasia and/or dislocation of the hip (DDH) is 1-4 in 1000 live births. It is observed 4-5 times more in girls. The risk of incidence in the first-born child is higher. The prevalence in the left hip alone is 67% (Tümer and Ömeroğlu, 1997, Sağlam, *et al*., 2014). More than one factor plays a role in DDH etiology, mechanical structural factors (connective tissue relaxation, capsular structure and such acetabular structures as labrum, pulvinar, ligamentum teres and transverse acetabular ligament), genetic (characteristics of the race and sex) and mechanical environmental factors (oligohydramnios, breech delivery, first labor and postnatal position) are important. DDH is observed more frequently in babies in swaddle with the history of prenatal breech position or breech delivery, multiple pregnancy or oligohydramnios having such accompanying deformities as torticollis, metatarsus adductus and pes calcaneovalgus (Köse, *et al*., 2010). The prevalence of DDH in the world ranges between 1‰ -1.5‰ (Ege, 1994, Tümer and Ömeroğlu, 1997, Bursalı, 2007, Barlow, 1962, Jones, 1977, Köse, *et al*., 2010). According to two well-known healthy studies in our country, the prevalence varies between 1.49% and 1.34% (Bayındır and Tanış, 1970, Kutlu, 1992, Köse, *et al*., 2010).

Classification:

DDH is classified under two main titles (Ünüvar, 2006, Sağlam, *et al*., 2014):

1. Teratologic DDH
2. Typical DDH

Teratologic DDH:

This form is observed together with such severe deformities as lumbosacral agenesis, chromosomal abnormalities, arthrogryposis multiplex congenita and myelomeningocele. In utero early period, it progresses with soft tissue contractures and displacement of femoral head (Sağlam, *et al*., 2014). These hips are displaced before birth, range of motion is limited (Ünüvar, 2006). The dislocation which exists at birth cannot be reduced with Ortolani maneuver (Ege, 1994, Tachdjian, 1990, İnci, 2005). These cases resistant to treatment constitute a small percentage (Tachdjian, 2002, Ünüvar, 2006).

Typical DDH:

Other abnormalities don't accompany. The child is completely normal. It can occur in utero (fetal, antenatal, prenatal), at birth (perinatal) or postnatal period (Sağlam, *et al*., 2014). Typical hip joint is composed of the instability in which femoral head in neonatal can be partially from acetabulum (subluxated) or completely (dislocated) displaced by the examiner, or dislocated hip can be reduced by the physician. The disorder is more apparent in advanced childhood or adolescence (Ünüvar, 2006). Typical DDH is classified into three sub-titles (Tachdjian, 1990, İnci, 2005):

1. ***Dislocated hip:***

The connection between femoral head and acetabulum is completely lost. It is situated in superolateral of main acetabulum (İnci, 2005). Perinatal typical dysplasia of the hip in neonatal period is reduced with flexion-abduction (Ortolani).

2. Dislocatable hip:

Femoral head is inside the acetabulum, but it can be easily displaced from acetabulum with Barlow's provocation test (İnci, 2005). This form is also called "unstable hip" (Sağlam, *et al*., 2014).

3. ***Subluxatable hip:***

Although femoral head is inside the acetabulum, a part of it has partially changed its place towards lateral and superior part (Sağlam, *et al*., 2014). It is characterized by ligamentous hyperlaxity, and femoral head can be partially dislocated outside the acetabulum with Palmen's subluxation provocation test (İnci, 2005).

Clinicial and Radiological Findings:

It has been stated that clinical and/or ultrasonographic instability has been found in nearly 5 out of 100 babies, but it spontaneously ameliorated in approximately 90% of them around the 6th week. The side with detected dysplasia during the examination is less mobile. Leg is relaxed and muscle tone has reduced. Leg is in external rotation. Trochanteric region of displaced part is more protruding than the opposite part. Displaced part gluteal area is hypotrophic and soft. Upper parts of femurs are far from each other in bilateral dislocations. Knee and hip flexion contracture normally seen in the first months of neonatal is not observed in children with bilateral dysplasia of the hip. Both inguinals are deeper and longer than normal. The methods used to diagnose DDH are below (Ömeroğlu, 2003):

Ortolani Test: This test named for his name in 1936 and being up-to-date even today is a test for dislocated head inside-outside the acetabulum.

Barlow's test: Barlow suggested in 1961 that dislocation may not give sufficient sound, and a dislocated hip can be evaluated as normal after a soft dislocation (Ömeroğlu, 2003).

Limited abduction: Limited abduction in the hip in neonatal period can be the only finding of the examination.

Pili asymmetry: In the baby laid down in supine or facedown position, there are normally several folds or plicas (pili) between inguine and knee, between gluteal area at the back and popliteal fossa. They are equal and symmetric in terms of number and depth. The number and depth of plicas in both legs of those with unilateral dysplasia of the hip are not the same, they are asymmetric.

Allis (Galeazzi) Sign: When both knees are flexed to 90 degree, and they are laid together, they should be on the same plane. But if the hip is dislocated, lower extremity will shorten in the dislocated part, so the knee of this part is lower. If a ruler is put on the knees flexed to 90 degrees side by side, and the ruler is not straight, a slope towards the dislocated part is observed.

Telescope (piston) sign: When femur is moved up and down as supported from ilium, the moves of femoral head in and out of acetabulum can be felt.

Thomas test: In case of the absence of physiological flexion contracture that must exist in neonatal period, DDH should be discussed.

Trendelenburg's sign: In children with developmental dysplasia of the hip that was ignored until the walking age, it is a sign related to shortening and weakening of gluteus medius muscle cleaved into trochanter major due to elevated proximal femur.

Direct anterior-posterior (AP) pelvis graphy is still the main evaluation method in the radiologic diagnosis and treatment of DDH. In this graphy, the relation between femoral head and acetabulum is clearly indicated to a large extent, and many significant distances and angles can be measured in this graphy (Ömeroğlu, 2003).

Treatment Methods with Salter Innominate Osteotomy:

In patients of walking age without receiving any treatment, phase 4 DDH is observed by Tönnis classification. Following the open reduction that is performed on those patients, it is generally difficult to ensure stability within the reliable limits. Whether an acetabular attempt is required should be determined by evaluating the stability during operation (Bozkuş, 2008). The most frequently used pelvic osteotomies are Salter innominate osteotomy, Pemberton osteotomy, Sutherland osteotomy, Steel (triple) osteotomy, Ganz periacetabular osteotomy, Chiari osteotomy, Shelf osteotomy (Morissy and Weinstein, 2001, Görgeç, 2007, Gülman, 2007, Bozkuş, 2008, Aksoy and Kara, 1997).

Regarding innominate osteotomies-one of the reconstructive procedures-depending on the principle that hyaline cartilage is rerouted by ensuring the redirection of the acetabulum around the head, hyaline cartilage are functioned without changing the shape of acetabulum. The purpose is to change total direction of acetabulum. Salter stated that the purpose of DDH treatment is to provide a normal anatomical structure and function as much as possible, and accordingly a concentric reduction should be provided and this reduction should be preserved (Salter, 1978, Rodolfo, 1974, İnci, 2005). Salter procedure has been put forth with the hypothesis that the major problem in DDH is the maldirection of acetabulum or excessively acetabular antetorsion (Tachdjian, 1990, Kunt, *et al*., 1997). It is the excessive anterior and extraversive position of the acetabulum instead of the downward position. And this negatively affects the stability. The hip maintaining its stability in abduction and internal rotation position loses the stability with the load position (extension+adduction).

While the anterior of the head is open in extension, lateral cover is inadequate in adduction. In that case, if the acetabulum can be provided with its normal position, the reduction performed will gain stability (Salter, 1966, Tachdjian, 1982, İnci, 2005, Tachdjian, 1990). According to Salter, the reason of instability is that acetabulum is in the forward and side looking position more than normal. Unless the deformities in proximal femur are not excessive, they recover following the attempt made to acetabulum. Salter states that development capacity of acetabulum is sufficient in DDH cases that can be reduced within the first 12 months, and dysplasia will disappear completely in time. Return of the dysplasia in the cases over eighteen months is very limited and

so, open reduction alone is not adequate in the cases over the age of 1.5 (Salter, 1966, İnci, 2005, Pemberton, 1965, Kunt, *et al*., 1997, Aksoy and Kara, 1997).

In the light of these information, the purpose in Salter's method can be uttered as making the hip stable even in the load position (Tachdjian, 1982, İnci, 2005).

Indications of Salter Innominate Osteotomy:

1- *Hip dislocations:* It can be performed for unilateral congenital hip dislocation that was never treated, or those residual or recurrent hip dislocations as a result of unsuccessful treatment between the ages of 1.5 and 7.

2- *Subluxation:* It can be performed for congenital hip subluxation that was never treated, or those residual or recurrent hip subluxations as a result of unsuccessful treatment at any age from 1.5 months to adulthood (Salter, 1966, Ünüvar, 2006).

Prerequisites for Salter Innominate Osteotomy:

- Complete and concentric reduction of the hip should be ensured. This is provided with the open reduction performed with innominate osteotomy.
- Positioning the femoral head opposite the acetabulum
- Existence of normal or near-normal hip movements
- Removal of the contractures in hip adductors and iliopsoas muscle
- Harmony between femoral head and acetabulum
- Appropriate age selection (Salter, 1966, Ünüvar, 2006).

Biomechanics of Salter Innominate Osteotomy:

Innominate osteotomy is performed between SIAI and big sciatic notch transversely over acetabulum. Following the osteotomy, the distal part of innominated bone containing the whole acetabulum rotates downward, forward and sideward over an axis between the osculation point in posterior osteotomy and symphysis pubis. This rotation redirects the acetabulum (Rab, 1978, Ünüvar, 2006). The capacity and encircling external lines of acetabulum don't change. One new position is preserved with a triangle graft put in between them. Salter osteotomy doesn't centralize the femoral head. Following the osteotomy, an increase in CE angle occurs after innominate osteotomy increases the moments of forces affecting the hip. As the femoral head is covered by acetabulum better, contact surface between the functional positions increases. The force that occurs following the load spreads to a wider surface and it prevents the development of degenerative arthritis. Obturator asymmetry that occurs as a result of salter innominate osteotomy arises from the rotation of distal fragment (Rab, 1978, Ünüvar, 2006, Babacan, *et al*., 1987, Chiari, 1974).

Complications of Salter Innominate Osteotomy:

1- Postoperative early complications
- Superficial and deep wound infection
- Retroperitoneal hematoma

2- Sciatic nerve injury
3- Femoral nerve injury
4- Wire problems: migration of K wire
5- Correction loss following the dislocation and crush of bone graft
6- Repositioning of distal segment to medial
7- Postoperative hardness in the hip
8- Progressive lateral and upward resubluxation and redislocation
9- In a patient with the preoperative lower extremity, excessive correction leads to prolongation on the operated part and difference of length between lower extremities.

Compensatory scoliosis can develop. Load on femoral head increases as a result of the displacement of distal fragment to the caudal.

10- Avascular necrosis (Ünüvar, 2006, İnci, 2005).

Application:

In the study, we included 7 patient operated on different dates. The age range of patients changed between 19-26 months. All patients were girls and they all had unilateral ignored total developmental dysplasia of the hip. The patients were brought by their parents with such complaints as delayed walking, failure to walk, limping and deformity of legs. All patients were diagnosed after the examination and direct graphy. Due to the fact that patients' hips were not reduced or as they were instable, they were directly operated without the need for arthrographic examination or additional treatment. All our patients hadn't received any treatment before referring to us. The purpose of the application is to evaluate the hip stabilities and results of the patients on whom salter innominate osteotomy (without femoral osteotomy) and soft tissue operation have been applied.

Quadriceps were given to the hips of all patients from iliac crest with anterior incision under general anesthesia. Salter innominate osteotomy was applied, the area of osteotomy was grafted with iliac crest triangular graft, stabilization was ensured with 2 percutaneous kirschner wires and the stability of the hip was observed to be not enough. Capsulotomy was performed, resection of teres and pulvinar tissue of ligamentum was conducted. The hip was reduced, it was seen that femoral head was sufficiently covered by acetabulum, capsular imbrication was performed, quadriceps were sutured to the original place following the pre-op stability control and the layers were closed by placing drain. Peli pedal circular plaster was applied on all patients, pre-op x-ray test was carried out after the plaster. X-ray controls of all patients were conducted on postoperative 2nd and 6th week, and kirschner wires and plasters were removed at the 6th week. It was observed Kirschner wire migration in 2 patients and soft tissue infection in 3 patients. In follow-ups, it was concluded that the hips were stable, leg lengths were equalized, range of movement was open and patients could walk 1-3 months after the removal of postop plaster.

Discussion:

Salter innominate osteotomy changes the orientation of the acetabulum with a bad position without changing the shape and capacity, and increases the load field of acetabulum, so this positively affects the development of acetabulum. The most important factor in developmental dysplasia of the hip determining the result is diagnosis and the time of treatment, so it is possible to obtain near-normal results (Tümer and Ömeroğlu, 1997, Okur, *et al*., 1996). The prevalence of developmental dysplasia and/or dislocation of the hip (DDH) is 1-4 in 1000 live births. It is observed 4-5 times more in girls. This great potential for the improvement in cases of developmental dysplasia of the hip in the period up to 18 months ensures the pretty good respond to conservative methods. However, the respond of acetabulum and femoral head to conservative methods after this age is inadequate, and a residual dysplasia or subluxation is faced in the future (Tümer and Ömeroğlu, 1997, Sağlam, *et al*., 2014). Salter and Dubos (1974) (Tümer and Ömeroğlu, 1997) have stated 94% perfect and good results with this method in children aged between 18 months and 4 years (Sarban, *et al*., 2006, Altınel, 1994, Weinstein and Ponseti, 1979).

Innominate bone osteotomy as defined by Salter in 1961 for dislocated and/or subluxated dysplasia of the hip changes the orientation of the acetabulum with a bad position without changing the shape and capacity, and increases the load field of acetabulum, so this positively affects the development of acetabulum. As a result, Salter operation is a current and successful method on condition that pre-operative rules and operation techniques are applied completely and thoroughly in children aged over 1.5. Corrective osteotomies should be added to femoral head in this operation for children aged over four (Kapukaya, 2000).

In our study, Salter Innominate Osteotomy application and soft tissue (ligamentum teres excision, pulvinar excision, capsular imbrication) operations were performed on 7 patients aged between 19 and 26 months. We are of the opinion that performing Salter Innominate Osteotomy together with soft tissue operations in total hip dislocations is important for hip reduction and anatomic restoration. Prolonged capsular imbrications mechanically prevent dislocation. Teres and intrarticular pulvinar tissue of prolonged ligamentum poses a mechanic obstacle for reduction. During the surgery of the cases with total dislocation, it was observed that although osteotomy alone provides adequate cover, it fails to satisfy stable reduction but the hip stability was maintained following the soft tissue operations. Pre-op stability, early post-op and late stability of the hip is important in all cases. To our knowledge, the anatomic hip we obtained with soft tissue operations is important for our cases to walk early and without limping. As capsulotomy is required for soft tissue operations, the possibility of femoral head and vessels to be damaged and septic arthritis risk are disadvantages.

Conclusion:

In our clinical cases, we observed that salter innominate osteotomy technique provides adequate cover on femoral head, it is sufficient in maintaining hip stability with soft tissue operations in total hip dislocations, and there were no complications observed except the simple complications like wire migration and soft tissue infection. It was seen that the patients between 19 and 26 months old on whom we performed operation walked early (1-3 months after the removal of plaster) after the operation.

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